

a. m. The time at Lawrence is given as 9.10 by one man and 9.15 by another. Assuming this time as 9.13 we have the following velocities of progression: Fiskdale to N. Billerica, distance, 51 miles; velocity, 44 miles per hour. N. Billerica to Lawrence, distance, 12 miles; velocity, 55 miles per hour. Lawrence to Newburyport, distance, 17 miles; velocity, 54 miles per hour.

These results are very satisfactory, and show a velocity of nearly a mile a minute near Lawrence. On examining the weather map just an hour before the tornado we find a general storm of slight intensity central 350 miles to the northwest of Lawrence. The velocity of this storm was 39 miles per hour. Reports from more than 30 stations about Lawrence show that just at this time, or a little before, the wind was gentle and from a southerly direction. Clouds were moving from following directions at 8 a. m.:

Southwest: Killington Peak, Vt.; Northfield, Vt.; New London, Conn.; Block Island, R. I.; Nantucket, Mass.; Mount Washington, N. H.

South: New Haven, Conn.; Boston, Mass.; Manchester, N. H.; Portland, Me.; Green Mountain, Me.; Eastport, Me.

The directions of clouds are shown slightly from sw. to the west of Lawrence but emphatically from s. near that town and on the east side. The wind at Killington was sw. 30; Mt. Washington, sw., 32; Green Mountain s. 34, with maximum in 12 hours of 60 s.

The tornado first struck about  $\frac{1}{4}$  mile west of Lawrence in an orchard which it damaged. It then passed to the grounds of the Cricket Club (several acres inclosed by a tight board fence 8 ft. high). This fence was levelled, and, except for a short distance on the southwest corner, was thrown outward from the centre in every direction. Farther on the tornado struck two dwellings on Emmet street, the most westerly in the city proper; one of these was carried east and nearly ruined, the other was completely demolished, with loss of life and buildings damaged. Just east of this the Essex Company's "Old Blue Ledge," an abandoned stone quarry, deflected the tornado upward over a thickly populated region and the houses escaped with the loss of chimneys. Cutler's house on Salem street was destroyed and near here, "just at one side of the track of the current," a portion of the roof of a church was lifted from the walls, as would happen if an outreaching arm of the cloud by powerful suction operating upon a particular point had produced the result, this was singular, inasmuch as the main building, higher and nearer the main current, was practically uninjured. From this point the progress was for some 100 rods or more across open ground to Springfield street, where the most damage was done to buildings and where the greatest loss of life occurred. "There seemed to be, at times, two whirls in the cloud, diverging slightly and reuniting as all swept swiftly on in a general direction slightly north of east. Here some buildings, apparently in the direct track, were left untouched or only slightly damaged while those on either side were demolished. In one case a large three-storied block was nearly stripped of the easterly, northerly, and westerly outer walls, the interior partitions and rooms appearing but little damaged, furniture and plastering therein remaining in position. Another large three-storied block upon the north side of the tornado's track appears to have been lifted from foundations and thrown south some 20 feet into the street, as would occur from a powerful suction upward and toward the centre." "At another point near the park a building upon the south side of the whirl was unroofed and thrown from foundation outward some 15 feet toward the

southeast, while nearly opposite, upon the north side of the whirl, a large dwelling was thrown outward northerly or more exactly toward the northwest. These cases are exceptional; the general position of debris, etc., indicates a powerful draught toward the centre and in the direction of movement."

A house on the corner of Market and Union streets, one block north of the track, was moved 8 feet to the west. On the north of the track and near it north windows of houses were invariably blown into the rooms, and small trees in the back yards were broken toward the south, or toward the path of the storm. In one case a small house that stood back of a house on the north of the street was blown southwest against a dwelling house and this in turn was strewn in fragments southeast. An interesting action was found in Union Park. A map showing the distribution of fallen trees will be found on the back of chart i. The characteristic indrafts on the right-hand side, and extending to 200 feet and more from the track, are well shown. There are a few trees on the left-hand side which indicate a counter current or a pushing through of the current on the right side, but the general position of the trees is, just as in the case of the houses, toward or in the direction of the tornado.

General direction of path was N. 60° E., about 35 houses were demolished or injured, 8 persons were killed and 68 injured. Very heavy rain fell before the tornado, and but little after its passage; no lightning or thunder was reported, and no hail fell; great quantities of timber and other articles were carried up and forward.

The cloud passed near one man working about one mile east of the town. It unroofed a barn (the first building injured) and then passed on through a grove. He described it as a large cloud rolling over and over. He heard a loud roar. Another observer saw the black cloud half mile away. He saw through the heavy rain what appeared to be two clouds chasing each other around in a whirl, the cloud in front was moving northerly. Another observer saw the top of the cloud rolling forward faster than the bottom, like the upper part of a wagon wheel.

#### WATER-SPOUT.

Pensacola, Fla., 21st: a well-defined water-spout was observed 3.30 p. m., 75th meridian time, near the middle of Escambia Bay, about  $6\frac{1}{2}$  miles east-northeast of this city. It moved in a westerly direction to the shore of Magnolia Bluff, a distance of about  $2\frac{1}{2}$  miles, in about 10 minutes. Observers report that the cloud presented the usual funnel shape, with the swell at the base. The column had an undulating, serpentine-like motion, and was estimated to be about a mile in length from the surface of the water to the contact with the cloud above, and about 25 feet in diameter. The water appeared to be sucked up a distance of about 10 feet, above which the column resembled mist or cloud. On reaching the shore the column broke at a point about  $\frac{1}{2}$  of its height, and in about 5 or 6 minutes it had dissipated.

### INLAND NAVIGATION.

#### STAGE OF WATER IN RIVERS AND HARBORS.

The following table shows the danger-point at the several stations; the highest and lowest water during July, 1890, with the dates of occurrence and the monthly ranges:

Heights of rivers above low-water mark, July, 1890 (in feet and tenths).

Stations.	Danger-point on gauge.	Highest water.		Lowest water.		Monthly range.
		Date.	Height.	Date.	Height.	
<b>Red River:</b>						
Shreveport, La.	29.9	1	11.1	31	1.4	9.7
<b>Arkansas River:</b>						
Fort Smith, Ark.	22.0	1	3.8	22	0.5	3.3
Little Rock, Ark.	23.0	2	7.3	31	4.0	3.3
<b>Missouri River:</b>						
Fort Buford, N. Dak.		1	11.0	31	6.2	4.8
Sioux City, Iowa.		7	11.8	31	9.0	2.8
Omaha, Nebr.	18.0	8	11.6	31	9.3	2.3
Kansas City, Mo.	21.0	15	14.5	31	10.2	4.3
<b>Mississippi River:</b>						
Saint Paul, Minn.	14.5	1	5.7	31	2.7	3.0
La Crosse, Wis.	24.0	1	8.0	31	4.4	3.6
Dubuque, Iowa.	16.0	1	12.5	31	4.7	7.8
Davenport, Iowa.	15.0	1	10.9	31	3.0	7.9
Keokuk, Iowa.	14.0	1	12.6	31	3.2	9.4
Saint Louis, Mo.	32.0	1	20.5	31	10.9	9.6
Cairo, Ill.	40.0	2	23.3	24-27	12.5	10.8
Memphis, Tenn.	34.6	1	18.6	27	10.3	8.3
Vicksburg, Miss.	41.0	1	28.5	31	13.0	15.5
New Orleans, La.	13.0	1	10.6	31	4.5	6.1
<b>Ohio River:</b>						
Pittsburgh, Pa.	22.0	28	6.2	12	1.3	4.9
Parkersburg, W. Va.	38.0	3	13.3	29, 31	2.8	10.5

#### Heights of rivers—Continued.

Stations.	Danger-point on gauge.	Highest water.		Lowest water.		Monthly range.
		Date.	Height.	Date.	Height.	
<b>Ohio River—Continued.</b>						
Cincinnati, Ohio.	50.0	6, 7	19.0	18	6.1	13.9
Louisville, Ky.	25.0	7, 8	8.5	30, 31	4.4	4.1
<b>Cumberland River:</b>						
Nashville, Tenn.	40.0	5	3.4	18, 19, 21, 22	1.5	1.9
<b>Tennessee River:</b>						
Chattanooga, Tenn.	33.0	28	7.7	17	2.0	5.7
<b>Monongahela River:</b>						
Pittsburgh, Pa.	29.0	28	6.2	12	1.3	4.9
<b>Savannah River:</b>						
Augusta, Ga.	32.0	26	18.3	16	5.0	13.3
<b>Willamette River:</b>						
Portland, Oregon.	15.0	1	12.4	28, 29, 30	7.0	5.4

#### LOW WATER.

**Ohio River.**—Navigation between Parkersburgh, W. Va., and Pittsburgh, Pa., was suspended on the 16th on account of low water.

**Cumberland River.**—Navigation closed on the 14th at Nashville, Tenn., on account of low water.

**Arkansas River.**—On the 22d the river at Fort Smith, Ark., was lower than it had been since April, 1887.

#### HIGH TIDES.

The tide was unusually high at Pensacola, Fla., on the 23d, and at Key West, Fla., on the 31st.

## ATMOSPHERIC ELECTRICITY.

### AURORAS.

Auroras were reported as follows: 3d, South Canisteo, N. Y. 5th, Beverly, N. J. 6th, Orono, Me.; South Canisteo, N. Y. 7th and 9th, Vevay, Ind.; Quakertown, Pa.; South Canisteo, N. Y. 11th, Salem Corners, Pa.; South Canisteo, N. Y. 12th, South Canisteo, N. Y. 14th, Vevay, Ind. 15-16th, Sandusky, Ohio. 16th, Orono, Me.; Davenport, Kimball, and Webster, S. Dak. 16-17th, Huron and Rapid City, S. Dak.; and Fort Buford, N. Dak. 17th, Newburyport, Mass.; Thornville, Mich.; and South Canisteo, N. Y. 17-18th, Saint Vincent, Minn. 18th, Green Bay, Wis.; Orono, Me.; Quakertown, N. Y.; and Salem Corners, Pa.

Sandusky, Ohio, 15th: at 10 p. m. a dark segment was observed above the northern horizon, extending from northwest to north-northeast, and at 10.30 p. m. beams of light appeared. The aurora attained its maximum brilliancy at 11 p. m., at which time the sky in the north was of a white misty appearance, while in the southeast the sky was illuminated by distant lightning. The display lasted until 2 a. m., 16th.

Huron, S. Dak., 16th: a brilliant aurora was observed at intervals from 10 p. m. until after midnight. Beams of light rose to about altitude 40°, and extended from north to east-northeast, producing a light which at times was almost as bright as that of the full moon.

Fort Buford, N. Dak.: an auroral light was observed 11.22 p. m., 16th, consisting of slender streamers of yellowish or straw color which had an upward and lateral motion and reached altitude about 60°. At 12.45 a. m., 17th, an arch of gray color formed, which rose to altitude 45°, and extended from northwest to east; at 1.30 a. m. the arch had receded some, the outlines were dimmer, and the streamers less numerous, and at 3 a. m. the aurora had disappeared.

Rapid City, S. Dak., 16th: a diffused auroral light, resembling the dawn of morning, was observed in the north from 11.30 p. m. until midnight. The light rose to altitude 45° and extended from azimuth 150° to 230°.

Saint Vincent, Minn.: a brilliant aurora was observed from 10.20 p. m., 17th, to 1.35 a. m., 18th. It consisted of 14 well-defined streamers, about one-half of which rose to altitude 70°, and varied in color at short intervals from a deep orange to a pale pink. The maximum brilliancy of the display occurred at 11.36 p. m., 17th, when the aurora extended from azimuth 160° to 225°.

Green Bay, Wis., 18th: an auroral display was observed at 2 a. m., consisting of an arch of white light in the north which rose to altitude about 15°, and extended from azimuth 135° to 225°. At altitude 25° in the northwest, a curtain-like appendage was seen.

### THUNDER-STORMS.

The more severe thunder-storms of the month are described under "Local storms." East of the Rocky Mountains thunder-storms were reported in the greatest number of states, 32, on the 15th; in 31 on the 8th; in 25 to 30 on the 2d, 3d, 9th, 16th, 17th, and 18th; in 20 to 24 on the 1st, 4th, 7th, 13th, 14th, 19th, 20th, 24th, 26th, 28th, and 29th; and in 14 to 19 on the 5th, 6th, 10th, 11th, 12th, 21st, 22d, 23d, 25th, 27th, and 30th.

East of the Rocky Mountains thunder-storms were reported on the greatest number of dates, 29, in Fla. and Miss.; on 20 to 28 in Ark., Ga., Iowa, Kans., La., Mich., Minn., Mo., N. Y., N. Dak., S. C., Tenn., and Tex.; on 12 to 19 in Ala., Ill., Ind., Ky., Md., Mass., Nebr., N. H., N. J., N. C., Ohio, Pa., S. Dak., Vt., Va., and Wis.; and on 1 to 10 in Conn., D. C., Ind. T., Me., Mont., R. I., and W. Va. West of the Rocky Mountains thunder-storms were reported as follows: Ariz., 1st to 31st; Colo., 1st to 11th, and 13th to 31st; Cal., 21st; Idaho, 7th to 15th, 21st, 22d, 23d, and 28th to 31st; Nev., 1st, 4th, 12th to 19th, 25th and 26th; N. Mex., 1st, 2d, 3d, 5th, 6th, 7th, 9th, 10th, 14th, 15th, 17th, 18th, 22d, 23d, 24th, and 26th to 31st; Oregon, 1st, 16th, 17th, and 31st; Utah, 1st to 5th, 13th, 14th, 15th, 17th to 20th, 25th to 29th, and 31st; Wash., 1st, 2d, 5th, and 9th; Wyo., 2d to 5th, and 18th to 22d. There were no states and territories in which thunder-storms were not reported.

## MISCELLANEOUS PHENOMENA.

### DROUGHT.

Drought injurious to crops and vegetation prevailed in Kans., Nebr., S. Dak., Minn., Iowa, Mo., Ark., Tex., Tenn., Ky., Ill., Ind., Ohio, Mich., N. Y., Mass., Md., Va., N. C., S. C., and Ala. The following is a summary of reports on drought made by regular and voluntary observers of the Signal Service:

**Kansas.**—The small precipitation and remarkably high temperature, preceded by a hot and dry June, caused serious damage to crops not matured by the first of the month. At Concordia crops suffered severely; wells, that never failed before, were dry; and the Republic River was the lowest ever known in July. At Alton crops were dried up. At Downs corn was ruined. At Elk Falls corn was estimated about  $\frac{1}{2}$  crop, and wells were becoming dry. At Fremont nearly all crops and a large proportion of fruit trees were destroyed. At Havensville corn was estimated about  $\frac{1}{2}$  crop, and potatoes and small garden vegetables were a failure. At Allison 80 per cent. of most crops was ruined. At Sedan corn, pastures, and apples were reported drying up. At Shields grass was dried up and corn a failure. At Wakefield corn was an entire failure in many fields, and the average yield was estimated at  $\frac{1}{2}$  crop, and fruit and vegetables were suffering. **Nebraska.**—At Culbertson the pastures were very dry; potatoes were a failure; and, in most cases, wheat and oats did not pay for the seed sown. At Genoa corn was injured. At Howe the drought that was injuring all crops was broken on the 17th. At Lexington corn was nearly destroyed. **South Dakota.**—At Woonsocket the ground was exceedingly dry; wells were becoming dry; and

all crops were unusually light. At Huron drought and hot winds had a bad effect upon late crops. At Webster vegetation was suffering. **Minnesota.**—At Montevideo and Sheldon crops were injured by drought. **Iowa.**—The month was characterized by periods of intense heat, with high winds and droughty conditions, making it one of the most unfavorable months for growing crops experienced since official observations have been taken. At Amana pastures and potatoes were suffering. At Dubuque the protracted drought was becoming serious in its results. At Blakeville all crops were injured. At Carson hot winds on the 6th, 7th, 13th, and 27th to 30th greatly damaged crops. At Clinton corn, potatoes, and pastures were suffering. At Des Moines the prospect for corn and potatoes was very poor; pastures were drying up; and cattle were suffering. At Fort Madison pastures were drying up; corn and garden vegetables were suffering; and wells were beginning to fail. At West Bend corn and potatoes were suffering. **Missouri.**—At Adrian all crops were suffering. Near Kansas City crops were reported a partial failure. At Harrisonville corn was injured. At Oregon crops and small fruit were damaged. At Platte River corn was injured. At Saint Charles all crops were suffering. At Steelville corn and pastures were injured. At Wither's Mills the corn crop seemed very light, and crops were suffering. **Arkansas.**—At Lead Hill corn and cotton were beginning to suffer, and in some localities corn appeared but about 25 per cent. of the usual crop. **Texas.**—At Mesquite the fruit crop was a failure; the long drought was broken by rain on the 4th. At Mountain Spring crops were almost a total